

## AMENDMENTS TO THE CLAIMS

In accordance with the PTO's amendment format, a detailed listing of all claims has been provided. A status identifier is provided for each claim in parentheses following each claim number. Changes to the claims are shown by strikethrough (for deleted text) or underlining (for added text).

### In the Claims:

- Claims 1-68 are pending in the application.
- Claims 2-3, 9-25, 32-40, 42, 46-50, 52-54, 56, 60-66, and 68-70 were previously withdrawn.
- Claims 1, 4, 8, 30, 41, and 55 are currently amended.
- Claims 1-68 are pending in the application.
- Claims 1, 4-8, 26-31, 41, 43-45, 51, 55, 57-59, and 67 are pending examination.

1 **Listing of Claims**

2  
3 1. **(Currently amended)** A method for use in detecting faces within a  
4 digital image, the method comprising:

5 processing a set of initial candidate portions of digital image data in a boosting  
6 filter stage that uses a boosting chain to produce a set of intermediate candidate  
7 portions; and

8 processing said set of intermediate candidate portions in a post-filter stage to  
9 produce a set of final candidate portions, wherein the post-filter stage includes an  
10 image pre-processing process, a color-filter process, and a support vector machine  
11 (SVM) filter process.

12  
13 2. (Withdrawn) The method as recited in Claim 1, further comprising dividing  
14 a digital image into a plurality of portions.

15  
16 3. (Withdrawn) The method as recited in Claim 2, wherein at least one of said  
17 plurality of portions has a shape selected from a group of shapes comprising a  
18 rectangle and a square.

19  
20 4. **(Currently Amended)** The method as recited in Claim 1, further  
21 comprising processing said plurality of portions using a pre-filter stage that is  
22 configured to output said set of initial candidate portions selected from said  
23 plurality of portions based on at least one feature.

1        5. (Original)    The method as recited in Claim 4, wherein said feature  
2 includes at least one feature selected from a group of features comprising a Haar-  
3 like feature, an extended feature, a mirror invariant feature, and a variance feature.

4  
5        6. (Original)    The method as recited in Claim 4, wherein said pre-filter  
6 stage includes a linear filter.

7  
8        7. (Original)    The method as recited in Claim 6, wherein said linear filter is  
9 based on a weak learner.

10  
11       8. **(Currently Amended)**    The method as recited in Claim 6, wherein said  
12 linear filter is based on a decision function of  
13  $H(x) = (a_1 f_1(x) > b_1) \wedge (a_2 (f_1(x) + r f_2(x)) > b_2)$ , wherein  $\alpha_i, b_i$  where  $i = 1, 2$  and  $r \in (-1, 1)$   
14 are coefficients determined during a learning procedure and  $f_1$  and  $f_2$  are features  
15 selected from a group of features.

16  
17       9. (Withdrawn) The method as recited in Claim 1, further comprising training  
18 said boosting chain using face images, non-face images, and weak classifiers.

19  
20       10. (Withdrawn) The method as recited in Claim 9, wherein said boosting  
21 chain includes a plurality of boosting nodes arranged in an order within said  
22 boosting chain.

23  
24       11. (Withdrawn) The method as recited in Claim 10, wherein said boosting  
25 chain is trained using boosting classifiers corresponding to said boosting nodes.

12.(Withdrawn) The method as recited in Claim 10, wherein a sample weight initialized for a current boosting classifier is adjusted based on a classification error rate of a previous boosting node within said order.

13.(Withdrawn) The method as recited in Claim 1, wherein said boosting chain includes a hierarchical chain structure.

14.(Withdrawn) The method as recited in Claim 1, wherein said boosting filter stage includes an LSVM optimization.

15.(Withdrawn) The method as recited in Claim 14, wherein said LSVM optimization is capable of finding a global maximum.

16.(Withdrawn) The method as recited in Claim 15, wherein finding said global maximum is based on:

Maximize: 
$$L(\beta) = \sum_{i=1}^n \beta_i - \frac{1}{2} \sum_{i,j=1}^n \beta_i \beta_j y_i y_j (h(x_i) \cdot h(x_j))$$

subject to the constraints  $\sum_i \beta_i y_i = 0$  and  $C_i \geq \beta_i \geq 0$ ,  $i = 1, \dots, n$ , and wherein coefficient  $C_i$  is set according to a classification risk  $w$  and trade-off constant  $C$  over a training set

$$C_i = \begin{cases} wC & \text{if } x_i \text{ is a face pattern} \\ C & \text{otherwise} \end{cases}.$$

17.(Withdrawn) The method as recited in Claim 1, wherein said post-filter stage includes image pre-processing and masking processing

1  
2 18.(Withdrawn) The method as recited in Claim 17, wherein said image pre-  
3 processing includes lighting correction processing.  
4

5 19.(Withdrawn) The method as recited in Claim 17, wherein said image pre-  
6 processing includes histogram equalization processing.  
7

8 20.(Withdrawn) The method as recited in Claim 1, wherein said post-filter  
9 stage includes at least a color filter process.  
10

11 21.(Withdrawn) The method as recited in Claim 1, wherein said post-filter  
12 stage includes at least an SVM filter process.  
13

14 22.(Withdrawn) The method as recited in Claim 1, further comprising  
15 outputting information associated with at least said final candidate portion.  
16

17 23.(Withdrawn) The method as recited in Claim 22, wherein said information  
18 identifies at least said final candidate portion.  
19

20 24.(Withdrawn) The method as recited in Claim 22, wherein said information  
21 includes at least said final candidate portion.  
22

23 25.(Withdrawn) The method as recited in Claim 22, wherein said information  
24 identifies rotation data associated with at least said final candidate portion.  
25

1       26.(Original)    The method as recited in Claim 1, further comprising  
2       employing at least one feature-based algorithm.

3  
4       27.(Original)    The method as recited in Claim 26, wherein said at least one  
5       feature-based algorithm uses Haar-like features.

6  
7       28.(Original)    The method as recited in Claim 26, wherein said at least one  
8       feature-based algorithm uses extended features.

9  
10      29.(Original)    The method as recited in Claim 26, wherein said at least one  
11      feature-based algorithm uses mirror invariant features.

12  
13      30. **(Currently Amended)**    The method as recited in Claim 29, wherein an  
14      extra constraint of the mirror invariant is added to reduce the size of a feature set  
15      associated with said mirror invariant features ~~are threshold configured~~.

16  
17      31.(Original)    The method as recited in Claim 26, wherein said at least one  
18      feature-based algorithm uses variance features.

19  
20      32.(Withdrawn) The method as recited in Claim 1, further comprising  
21      performing in-plane estimation to detect an orientation of said face image data.

22  
23      33. (Withdrawn) The method as recited in Claim 32, wherein said orientation is  
24      with respect to an up-right position.

1 34.(Withdrawn) The method as recited in Claim 33, further comprising  
2 performing up-right face detection based on said in-plane estimation.

3  
4 35.(Withdrawn) The method as recited in Claim 34, wherein said up-right face  
5 detection is configured to identify out-plane rotation variations of said face image  
6 data.

7  
8 36.(Withdrawn) The method as recited in Claim 35, wherein said out-plane  
9 rotation variations are within a range of  $\Theta = [-45^\circ, 45^\circ]$ .

10  
11 37.(Withdrawn) The method as recited in Claim 21, wherein said SVM filter  
12 process is performed in a redundancy reduced feature space.

13  
14 38.(Withdrawn) The method as recited in Claim 37, wherein said SVM filter  
15 process further includes performing wavelet transformation to divided the original  
16 images into four sub-bands LL,HL,LH and HH.

17  
18 39.(Withdrawn) The method as recited in Claim 38, wherein said SVM filter  
19 process is configured to reduce said redundancy based on

20 
$$k'(u, v) = \sum_{0 \leq i < 4} (s_i u_i^T v_i + r_i)^2$$
  
21 ,

22 wherein each vector  $u_i$  and  $v_i$  corresponds to an  $i^{\text{th}}$  sub-band portion.

23  
24 40.(Withdrawn) The method as recited in Claim 38, further comprising  
25 selectively cropping of four sub-band portions.

1  
2       **41. (Currently Amended)**     A computer-readable medium having computer-  
3 implementable instructions for causing at least one processing unit to perform acts  
4 comprising:

5       detecting possible human face image data within a digital image using a  
6 multiple stage face detection scheme that includes:

7       at least a ~~boosting~~ filter stage configured to process a set of initial candidate  
8 portions of digital image data using a boosting chain to produce a set of  
9 intermediate candidate portions[[],]; and

10       a post-filtering stage configured to process said set of intermediate  
11 candidate portions to produce a set of final candidate portions, wherein the post-  
12 filter stage includes an image pre-processing process, a color-filtering process, and  
13 a support vector machine (SVM) filtering process.

14  
15       **42. (Withdrawn)** The computer-readable medium as recited in Claim 41,  
16 further comprising dividing a digital image into a plurality of portions, and  
17 wherein at least one of said plurality of portions has a shape selected from a group  
18 of shapes comprising a rectangle and a square.

19  
20       **43. (Original)**     The computer-readable medium as recited in Claim 41,  
21 wherein said multiple stage face detection scheme further includes a pre-filter  
22 stage that is configured to output said set of initial candidate portions selected  
23 from said plurality of portions based on at least one feature.



1       44.(Original)   The computer-readable medium as recited in Claim 43,  
2 wherein said feature includes at least one feature selected from a group of features  
3 comprising a Haar-like feature, an extended feature, a mirror invariant feature, and  
4 a variance feature.

5  
6       45.(Original)   The computer-readable medium as recited in Claim 43,  
7 wherein said pre-filter stage includes a linear filter based on a weak learner.

8  
9       46.(Withdrawn) The computer-readable medium as recited in Claim 41,  
10 wherein said boosting chain is trained using face images, non-face images, and  
11 weak classifiers.

12  
13       47.(Withdrawn) The computer-readable medium as recited in Claim 46,  
14 wherein said boosting chain includes a plurality of boosting nodes arranged in an  
15 order within said boosting chain, said boosting chain is trained using boosting  
16 classifiers corresponding to said boosting nodes, and each of said boosting nodes  
17 is constructed based on its preceding node in said order.

18  
19       48.(Withdrawn) The computer-readable medium as recited in Claim 41,  
20 wherein said boosting chain includes a hierarchical chain structure.

21  
22       49.(Withdrawn) The computer-readable medium as recited in Claim 41,  
23 wherein said boosting filter stage includes an LSVM optimization.

1        50.(Withdrawn) The computer-readable medium as recited in Claim 41,  
2 wherein said post-filter stage includes a masking process, a lighting correction  
3 process, a histogram equalization process, a color filter process, and an SVM filter  
4 process.

5  
6        51.(Original) The computer-readable medium as recited in Claim 41,  
7 further comprising employing at least one feature-based algorithm that uses at  
8 least one feature selected from a group of features including at least one Haar-like  
9 feature, at least one extended feature, at least one mirror invariant feature, and at  
10 least one variance features.

11  
12        52.(Withdrawn) The computer-readable medium as recited in Claim 41,  
13 further comprising performing in-plane estimation to predict an orientation of said  
14 face image data and applying an up-right detector to pre-rotated image data  
15 corresponding to the orientation prediction.

16  
17        53.(Withdrawn) The computer-readable medium as recited in Claim 50,  
18 wherein said SVM filter process is configured to reduce redundancy in a feature  
19 space associated with at least one intermediate candidate portion, and performs  
20 wavelet transformation of said at least one intermediate candidate portion to  
21 produce a plurality of sub-bands portions.

22  
23        54. (Withdrawn) The computer-readable medium as recited in Claim  
24 53, further comprising selectively cropping at least one of said plurality of sub-  
25 band portions.

1  
2       **55. (Currently Amended)**     An apparatus comprising:

3       logic operatively configured to detect at least one human face within a digital  
4 image using a multiple stage face detection process that includes;

5       at least a boosting filter stage configured to process a set of initial candidate  
6 portions of digital image data using a boosting chain to produce a set of  
7 intermediate candidate portions[[]]; ~~and~~

8       a post-filter stage configured to process said set of intermediate candidate  
9 portions to produce a set of final candidate portions, wherein at least one of said  
10 final candidate portions includes detected face image data; and

11       wherein the post-filter stage includes an image pre-processing process, a color-  
12 filtering process, and a support vector machine (SVM) filtering process.

13  
14       **56. (Withdrawn)** The apparatus as recited in Claim 55, wherein said logic is  
15 further configured to divide a digital image into a plurality of portions, and  
16 wherein at least one of said plurality of portions has a shape selected from a group  
17 of shapes comprising a rectangle and a square.

18  
19       **57. (Original)**     The apparatus as recited in Claim 55, wherein said multiple  
20 stage face detection scheme further includes a pre-filter stage wherein said logic is  
21 configured to output said set of initial candidate portions selected from said  
22 plurality of portions based on at least one feature.

1       58.(Original)     The apparatus as recited in Claim 57, wherein said feature  
2 includes at least one feature selected from a group of features comprising a Haar-  
3 like feature, an extended feature, a mirror invariant feature, and a variance feature.  
4

5       59.(Original)     The apparatus as recited in Claim 57, wherein as part of said  
6 pre-filter stage said logic includes a linear filter based on a weak learner.  
7

8       60.(Withdrawn) The apparatus as recited in Claim 55, wherein said boosting  
9 chain is trained using face images, non-face images, and weak classifiers.  
10

11       61.(Withdrawn) The apparatus as recited in Claim 60, wherein to provide said  
12 boosting chain said logic includes a plurality of boosting nodes and a plurality of  
13 boot strap functions arranged in an alternating order within said boosting chain,  
14 and wherein said boosting chain is trained using boosting classifiers corresponding  
15 to said boosting nodes, and wherein at least one sample weight associated with one  
16 of said boot strap functions is adjusted based on at least one classification error of  
17 a weak classifier associated with a previous boosting node.  
18

19       62.(Withdrawn) The apparatus as recited in Claim 55, wherein said boosting  
20 chain is operatively arranged in a hierarchical chain structure.  
21

22       63.(Withdrawn) The apparatus as recited in Claim 55, wherein said boosting  
23 filter stage includes an LSVM optimization configured to determine a global  
24 maximum.  
25

1       64.(Withdrawn) The apparatus as recited in Claim 55, wherein as part of said  
2 post-filter stage said logic is further configured to perform at least one process  
3 selected from a group of processes that includes a lighting correction process, a  
4 histogram equalization process a color filter process, and an SVM filter process.

5  
6       65.(Withdrawn) The apparatus as recited in Claim 55, wherein said logic is  
7 further configured to output information associated with at least said final  
8 candidate portion, said information at least identifying said final candidate portion.

9  
10       66.(Withdrawn) The apparatus as recited in Claim 65, wherein said  
11 information includes rotation data associated with at least said final candidate  
12 portion.

13  
14       67.(Original)     The apparatus as recited in Claim 55, wherein said logic is  
15 further cooperatively configured to implement at least one feature-based algorithm  
16 that uses at least one feature selected from a group of features including at least  
17 one Haar-like feature, at least one extended feature, at least one mirror invariant  
18 feature, and at least one variance features.

19  
20       68.(Withdrawn) The apparatus as recited in Claim 55, wherein said logic is  
21 further operatively configured to perform in-plane estimation that detects an  
22 orientation of said face image data, and up-right face detection based on said in-  
23 plane estimation, wherein said up-right face detection identifies out-plane rotation  
24 variations of said face image data.

1       69.(Withdrawn) The apparatus as recited in Claim 64, wherein as part of said  
2 SVM filter process said logic is configured to reduce redundancy in a feature  
3 space associated with at least one intermediate candidate portion based on wavelet  
4 transformation of said at least one intermediate candidate portion that produces a  
5 plurality of sub-bands portions.

6  
7       70.(Withdrawn) The apparatus as recited in Claim 69, wherein said logic is  
8 further configured to selectively crop at four sub-band portions.